Notes from the PARCA Greenland Hydrology Breakout Session
The following notes were taken during the Greenland Hydrology Breakout Session at the 2014 PARCA meeting held at Goddard Space Flight Center. The notes were submitted for discussion, clarification and refinement to the PARCA list serve before submission to the NASA Cryospheric Sciences Program Manager. Facilitator: Lora Koenig. Note Taker: Charles Webb.

1) Major Science Questions in Greenland Hydrology

Why do we care about water?

- Ice Rheology and sliding, with impacts to ice dynamics.
- Discharge to ocean, with impacts to ice/ocean interactions and ocean currents.

How much water is on the ice sheet, in the ice sheet and coming out of the ice sheet?

- How and where does melting occur?
- What is the magnitude of the water input to all components of the hydrologic system?
- What is the routing, and how much is being retained? What is the residence time?

What happens to the water?

- How much water goes into the ground below the ice sheet?
- Where is water being input to the ocean?
- What is in the water ie. isotopic and chemical make up?

What processes drive water discharge from the ice sheet?

- How important are lakes vs. rivers to Greenland hydrology? What are their respective roles?
- What are the contributions from ocean terminating versus land terminating watersheds? How can we best quantify discharge from ocean terminating watersheds?

What characteristics of the ice sheet do we need to understand Greenland hydrology?

- Roughness characteristics
- Morphology of channels
- Locations of moulins and mapping of englacial channels

2) Measurement Needs-*What measurements? Where? How good are field network, satellite/airborne resources?*

- Need more proglacial stream gauges with improved technology for cold regions. Most are currently seasonal and require annual maintenance or gauging.

Fieldwork is challenging. It's labor-intensive. The gauges are delicate and need people to operate and to monitor them.

- We need to gauge supraglacial streams for entire seasons.
- We need a better understanding of the subglacial water system including Temperature, roughness, geology, etc. While additional borehole measurements are required they will always be limited in spatial scope. Long-term subglacial measurements and radar techniques should be explored and developed.
- Investigations on using isotopes or other tracers to gauge or map water flow in the ice.
- Groundwater measurements and fluxes to understand how much water can be retained.
- Velocity data and extent data at high temporal resolution. WorldView optical imagery data can give depth of water in surface rivers, but not the velocity. Also, this data is heavily impacted by the presence of clouds. Supplement or complement this data with airborne instruments or radar unaffected by cloud cover.
- Improved hyperspectral algorithms for deriving water depths.
- Measure water density changes in fjords with CTDs/moorings and relate this to freshwater discharge. Compare different fjords and different kinds of glaciers.
- Full suites of instruments for radiation balance, ocean properties, supra- and subglacial melt properties etc. should be made in regions that already have proglacial gauges.

3) What is Missing?

- Ice sheet models do not include hydrology. We need a better understanding of hydrological processes to including them in models, as they are likely a key to modeling ice dynamics.
- We should explore collaboration with non-traditional groups, such as the hydropower industry in Greenland, as they may have additional data, such as measurements from their own proglacial gauges. Additionally we should engage citizen scientists in Greenland to monitor streams. There are people living in these regions who could maintain water gauges with proper training.
- We should reach out to the oceanography community, to better connect hydrological processes to ice/ocean interactions and direct impacts of meltwater on ocean conditions.

4) Next Steps

By 2015

- Use WorldView satellite imagery data to catalog surface streams.

- Need additional work with radar remote sensing data, at highest possible resolutions, to image streams/ponds with sufficient temporal resolution to deal with clouds in optical imagery, especially in frequently cloudy regions.

By 2020

- A lot of progress could be made with additional fieldwork, including time-lapse photography. These instruments are typically monitored from nearby camps during the summer. Getting across big rivers, though, to put gauges in place, is a challenge – need helicopters.
- Develop a standard hydrologic model for Greenland. Incorporate GRACE and other satellite data as appropriate.

By 2030

- Establish AWS-like stations, for measuring water flow, installed on land- and water-terminating glaciers from the divide to the ocean in the high runoff basins in Western Greenland to establish maximum runoff and bound the problem.